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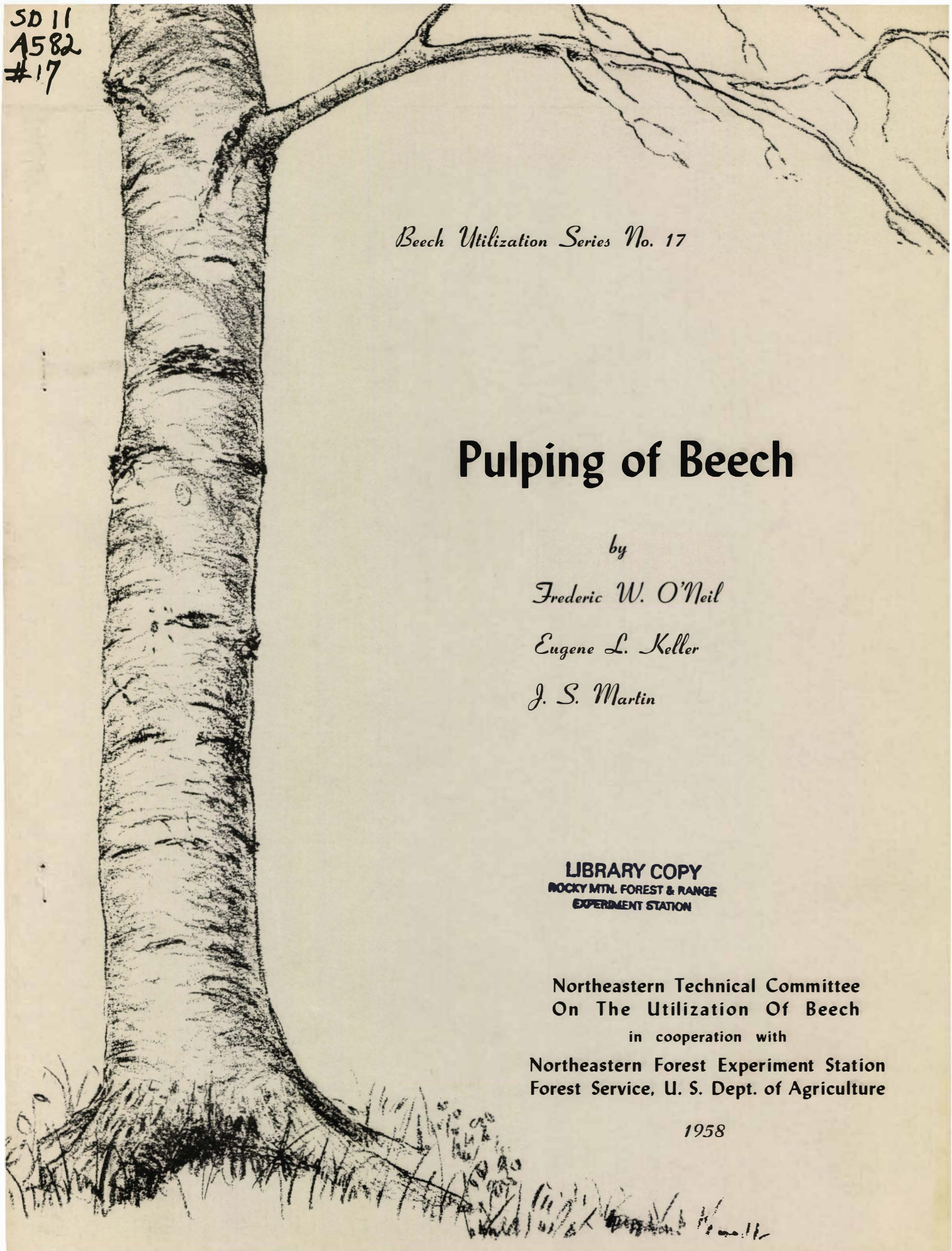

Beech Utilization Series No. 17

Pulping of Beech

by

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EXPERIMENT STATION

Northeastern Technical Committee
On The Utilization Of Beech
in cooperation with
Northeastern Forest Experiment Station
Forest Service, U. S. Dept. of Agriculture

1958

FOREWORD

The wood of the American beech tree (Fagus grandifolia Ehrh.) is well suited for a large number of uses, and it is rather widely used by manufacturers. Yet the amount used is not in proportion to the amount that grows in our northeastern forests. The utilization of beech--both in the woods and in the factory--has been recognized as a problem.

One reason for this is in the nature of the wood: it has a reputation for being difficult to season. Another is that many of the beech trees in our forests are of poor quality. And there are some plain prejudices against beech.

Research is finding ways to utilize beech as efficiently as any of the other comparable hardwoods can be handled. Considerable information about beech has been gathered. Yet most of this information is available only in fragmentary form in scattered technical reports. Some of it has never been published.

To study the problems of putting beech to the uses it deserves, and to promote the better management of the forests in which it grows, a Northeastern Technical Committee on the Utilization of Beech was organized in 1949. This committee, which includes representatives of Federal and State forestry agencies, universities, and state experiment stations, decided to assemble and publish the available information about the utilization of American beech.

As its part of this cooperative project, the Northeastern Forest Experiment Station has undertaken to edit, publish, and distribute the series of reports that will contain this information.

The subjects of these reports will be as follows:

* Physical and mechanical properties of American beech.

(CONTINUED ON INSIDE OF BACK COVER)

Pulping of Beech

by

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INTRODUCTION

The rapid growth of the pulp and paper industry during the last 15 years has intensified the search for additional sources of cellulose. The paper industry is wholly dependent for its raw material on cellulose--the universal plant substance.

Since development of the first chemical process for obtaining pulp from trees, we have looked on them as the ideal source of raw material. But because of the longer fibers found in the coniferous species, the industry has considered softwoods as the primary source of raw material for all types of papers. Recent technological advances, however, have shown that pulps manufactured from the hardwoods are equal in many properties to pulps from coniferous species.

[1]Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The availability and supply of American beech (Fagus grandifolia Ehrh.), its distribution, and other pertinent information dealing with the silvicultural aspects and harvesting of this species, as well as its chemistry and chemical utilization, are covered in other reports in this Beech Utilization series.

American beech is fairly widespread throughout the Eastern and Northeastern States, where it occurs mostly in mixed stands. Because of processing difficulties, it has not been cut as much as other hardwoods for use in wood products; thus, the proportional amount of beech in these stands has increased. About 23 million cords of beech are now available on commercial forest land in New York and the New England States. In volume, the species ranks fourth, along with red oak, among hardwoods available in the region (30).[2]

Pulp mills in the East and Northeast can no longer rely on preferred softwoods to supply all of the raw material needed for papermaking. Mills once favorably situated in regard to these softwoods are now compelled to ship them considerable distances or to adapt their processes and products to the use of woods closer at hand. Most of these are hardwoods, among which beech exists in large quantity. Beech has been used in mixture with birch, maple, and other hardwoods for the manufacture of pulp for many years, though it has not been as acceptable as most of the species with which it is associated. Until recently its principal use has been in the production of soda pulp.

This report describes the characteristics of beech as a pulpwood, how it reacts in various pulping processes, and the qualities of pulps it will yield.

PROPERTIES OF BEECH

American beech is among the heavier hardwoods that are of commercial importance. In tests made at the Forest Products Laboratory, the average specific gravities of wood from different sources ranged from 0.52 to 0.62, based on weight when moisture free and on volume when green; the average of wood from all sources was 0.57. American beech has a relatively wide sapwood band; sapwood constituted more than half of the average radius of 32 bolts taken from 26 trees cut in 4 localities, and comprised about 80 percent of the total volume of the bolts. In some trees, the heartwood is distinctly reddish in color, giving rise to the name "red

[2] Underscored numbers in parentheses refer to Literature Cited.

beech"; in others, it is so much lighter that it is called "white beech". Heartwood and sapwood, whether red or white, do not differ in physical or mechanical properties if they are of comparable density (34).

Beech is one of the more difficult woods to debark. Sap peeling is slower than with other associated hardwoods, and the sap-peeling season lasts only 6 to 8 weeks during April, May, and June. But chemical debarking has proved very successful (41).

The physical components of the hardwoods are vessels, fibers, and ray cells. Most important for pulp manufacture are the fibers, which in beech average about 1.2 millimeters in length, and the vessels, which average about 0.68 millimeter in length. These components compare favorably in size with those of the other dense hardwoods (table 1), such as birch and maple, but are much shorter than the tracheids of spruce (25).

Table 1.--Physical characteristics of woody tissues, by selected species

Species	Length of--		Volume of--			Density[1]
	Fiber	Vessel	Fiber	Vessel	Ray	
	Mm.	Mm.	Percent	Percent	Percent	Lb. per cu. ft.
Beech (Fagus grandifolia Ehrh.)	1.07 - 1.42	0.51 - 0.66	--	--	20	35.0
Maple (Acer saccharum Marsh)	.71 - .78	.30 - .34	61	21	18	35.6
Yellow birch (Betula lutea Michx)	1.15 - 1.4	.74 - 1.18	66	21	11	35.5
Aspen (Populus tremuloides L.)	.74 - 1.3	.45 - .71	53	33	14	22.6
Spruce (Picea glauca Voss)	[2] 3.1 - 3.3	-- --	[2] 93	--	6	25.0

[1] Based on weight when oven-dry and on volume when green.
[2] Tracheids.

Table 2 shows a comparison of the proximate analyses of beech, birch (Betula lutea) and European beech (Fagus sylvatica L.).

MECHANICAL PULPING

Mechanical pulp made from beech-like pulp of other hardwoods of similar density is very short fibered and has low strength compared to that obtained from softwoods commonly used. For example, the bursting strength of beech mechanical pulp was only 0.04 point per pound per ream, whereas spruce mechanical pulp averaged 0.3 point per pound per ream. The tearing resistance for beech pulp was like-

wise low, with a value of 0.14 gram per pound per ream as compared with 0.52 for spruce pulp. The fiber classification showed less than 1 percent of the beech pulp fibers retained on the 20-mesh screen, about 14 percent retained on the 150-mesh screen, and about 85 percent passing the 150-mesh screen. The classification of the spruce pulp was about 5 percent passing the 20-mesh, 53 percent retained on the 150-mesh, and 42 percent passing the 150-mesh screen (25) These characteristics show clearly that beech mechanical pulp can be used only in relatively small amounts as a filler stock in paper formulations.

Table 2.--Composition of heartwood and sapwood
(Based on weight of oven-dry wood)

Analysis of wood	Yellow birch[1]		American beech[1]		European beech[2]
	Heartwood	Sapwood	Heartwood	Sapwood	
	Percent	Percent	Percent	Percent	Percent
Ash	0.50	0.11	0.57	0.31	--
Solubility in cold water	.93	1.20	.23	1.23	--
Solubility in hot water	1.29	1.30	.43	2.17	--
Alcohol benzene	1.89	.97	.96	1.37	0.88
Ether	.30	.36	.57	.20	--
Acetyl	6.11	8.79	6.05	7.13	--
Methoxyl	6.04	6.01	6.44	6.25	--
Pentosans	26.87	26.89	24.49	25.55	22.1
Lignin	20.19	18.56	22.26	20.61	21.0
Cellulose	58.37	59.36	60.71	60.83	--
Holocellulose	76.45	79.50	76.85	76.20	--

[1]Freeman, R. D., and Peterson, F. C. Proximate analysis of the heartwood and sapwood of some American hardwoods. Industrial and Engineering Chemistry, Analytical Edition. Vol. 13, pp. 803-805.

[2]Data from State University of New York College of Forestry at Syracuse University, Syracuse, N. Y.

Beech mechanical pulp has a dark color and must be bleached for use in light-colored papers. In the foregoing experiments, beech pulp given a standard brightness test was rated at about 43 units, as compared with 62 units for the spruce pulp. Other literature (5, 39) substantiates these findings.

PRETREATMENT OF WOOD FOR GRINDING

Pretreatment of beech with steam, hot water, or various chemical solutions before it is ground softens the binding material and allows the grindstone to draw out longer fiber particles, which appreciably increase the strength

properties of the pulp, particularly when chemical solutions are used.

The use of water and steam as a pretreating medium has been practiced in plant operations for many years. The resulting pulp from beech, as well as those of other hardwood and softwood species, is dark brown in color, quite bulky, and somewhat stronger than pulp from the untreated wood. Steamed beech can be used to produce pulp for dense boards and artificial leather. Steaming results in lower energy consumption and dark color. When used in the furnish, steamed beech causes excessive amounts of foam (2).

The use of chemicals in the treating liquor resulted not only in a noticeable reduction in energy consumption but also in pulps with appreciably increased bursting and tearing strength, although darker pulp color was reported in all cases.

Further improvement in the physical properties of mechanical pulps is obtained by employing special pretreating methods involving the use of vacuum and hydrostatic pressure in the treating vessel. This procedure is the basis for the chemigroundwood process (25). A typical chemical solution used in this process contains 6 parts of sodium sulfite and 1 part of sodium bicarbonate at a concentration of 1 pound per gallon. The treating time is about 6 hours, the temperature may vary from about 130° to about 150° C., and the pressure is about 150 pounds per square inch.

Chemigroundwood pulp made from sound, dry beech wood is comparable in strength with spruce groundwood, but the usual run of beech pulpwood yields pulp of a quality below this standard (8). The strength and color of beech chemigroundwood pulp are inferior to those of pulps produced under similar conditions from aspen, birch, and maple (8, 25). Commercially, beech processed in mixture with these species is limited to about 10 percent of the mixture (14). Chemigroundwood pulp made from this mixture of woods is used in the manufacture of newsprint paper and corrugating board.

MECHANICAL PULP FROM CHIPS

Within the last few years, considerable interest has developed in the manufacture of a mechanical pulp from hardwood chips. In this process, the chips are first wetted with water, very weak caustic, or some other chemical solution. The chips are then metered into a screw press, where steam may be added if desired. After the chips pass through the press, they are fed into a single- or double-disk mill.

The press breaks the chips into smaller particles and the disk mill continues this refining action, producing a pulp that is equal to insulation board or coarse groundwood pulp. If further refining is necessary, the pulp is put through a second disk mill, which gives it characteristics similar to those obtained from spruce mechanical pulp for newsprint. These pulps may be used in newsprint or other types of papers as a substitute for part of the coniferous groundwood requirements (10).

There are many modifications of this process. Chips may be treated with water in a digester and then refined in a disk mill; or they may be treated with various chemicals, either under pressure in a digester or in cold solutions, before they are refined in disk mills. An example is the cold caustic soda pulping process developed at the U.S. Forest Products Laboratory, which consists of steeping chips in a solution of sodium hydroxide at room temperature before they are fiberized in a disk attrition mill.[3] This process is being used in one mill to prepare a high yield of pulp (90 percent) from a mixture of approximately 30 percent of beech with birch and maple. The pulp is refined and bleached in a single-stage calcium hypochlorite treatment. The bleached pulp is used as a partial substitute for bleached spruce groundwood pulp in book-type paper furnishes (11).

SODA PULPING

Beech pulps made by the soda process are characterized by their opacity, bulk, softness, and absorbency. These characteristics are typical of those found for other hardwood soda and sulfate pulps. Beech is seldom used alone for soda pulping, but more often in mixture with other available hardwoods, mainly birch, maple, and oak (see fig. 1).

The pulping characteristics of American beech are similar to those of maple. Beech is a little easier to pulp than birch, but more difficult than aspen (42).

Cooking conditions for beech fall within the range of those normally used for the soda process. Satisfactorily small amounts of screening rejects may be obtained with various combinations of the cooking variables, such as amount of chemical, cooking time, and maximum temperature (16). The amounts of active cooking chemical consumed in the pulping of beech and maple are practically identical. Birch consumes 1 percent more chemical and aspen 3 percent less than does

[3] Brown, K. J., and McGovern, J.N. High-yield cold soda pulps and products from several woods. Paper Industry 35 (1): 66-69. 1953.

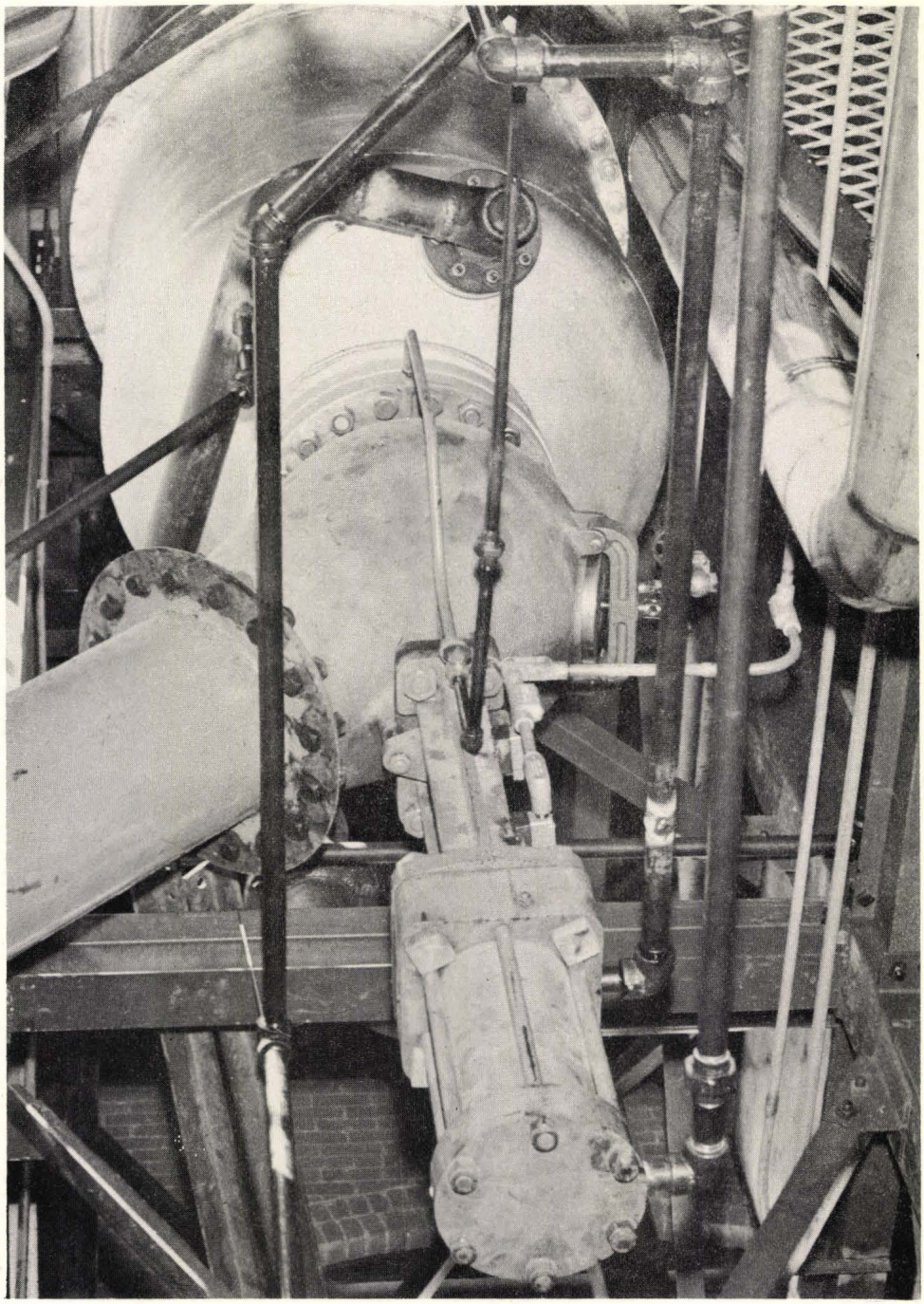

Figure 1.--Rapid cycle digester employed in a modern process for making cold soda pulp at a northern New York State mill. Significant quantities of beech are used in this process.

(Photo courtesy of Gould Paper Co., Lyons Falls, N.Y.)

beech or maple (42). A longer cooking time and a larger amount of chemical are required when bleaching is to be done in 1 or 2 stages with hypochlorite only, than when multi-stage chlorine-hypochlorite bleaching methods are to be used. Most of the published work on the experimental soda pulping of beech deals with the production of pulp more suitable for bleaching by older types of treatments rather than with higher pulp yields and improved strength.

Beech yields much less unbleached pulp on a weight basis than aspen. On a cord basis, where the density of the wood is taken into consideration, beech yields more pulp than aspen. The density of beech was considered to be an advantage in Germany, where a soda pulp mill was designed for production of beech filler pulp for book paper (36).

Beech soda pulps develop strength more slowly in the beater than aspen soda pulps (42). Relative strength values indicate that beech soda pulp has lower strength than aspen soda and sulfate pulps. Beech soda pulp has 58 percent as much bursting strength and 80 percent as much tearing strength as aspen sulfate pulp.

Beech soda pulp made by customary procedures is not considered to be a dissolving pulp suitable for conversion into viscose and acetate rayon (15). Experimental tests have indicated that pulp suitable for this purpose can be made by precooking the beech chips at elevated temperatures with steam, water, or one of several kinds of mineral acids, and following this treatment with customary soda cooking. This beech prehydrolysis soda pulp is considered more suitable for viscose than for acetate rayon (33).

SULFATE PULPING

Hardwood sulfate pulps are suitable for a large variety of papers, provided their special properties are properly exploited in use.

In the United States, limited quantities of beech are pulped by the sulfate process in mixture with birch, maple, oak, and aspen. A small amount of beech sulfate pulp produced commercially at Johannesmuehle, Germany, in 1946, was understood to have some papermaking value, but its use for chemical purposes was considered more promising (27).

American beech can be pulped by the sulfate process about as easily as maple, a little more easily than birch, but with more difficulty than aspen. It can be pulped satisfactorily by several combinations of the sulfate cooking variables, including those conditions conventionally used for pulping hardwoods.

Experiments indicate that nearly optimum pulp quality may be obtained by using a sulfate cooking liquor of 20 percent sulfidity, and that only two-thirds of this optimum quality will be obtained with a liquor of 5 percent sulfidity. The higher sulfidity figure represents 4 parts of sodium hydroxide to 1 part of sodium sulfide, whereas these chemicals are present in a ratio of 19 to 1 in the cooking liquor of lower sulfidity (21).

On a weight basis, the yield of sulfate pulp from beech is lower than that of birch and aspen sulfate pulps and higher than that of aspen soda pulp. On a cord basis, the yield of sulfate pulp from beech is much higher than that of aspen, because of the higher density of the beech wood.

Sulfate pulp made from beech has relative strength values generally less than those of aspen and birch. Because of the slow hydration tendencies of beech pulps, the relative strength values of the sulfate pulp would be even lower if comparisons were made on pulps having the same beating time. The relative strength values of beech sulfate pulps are higher than those of beech and aspen soda pulps. In comparison with unbleached spruce sulfate pulp, American beech sulfate pulp has 53 percent as much bursting strength, 69 percent as much tearing strength, 9 percent as much folding endurance, and 51 percent as much tensile strength (28).

The conventional one-stage sulfate cooking process is suitable for producing pulps from beech for paper. However, in use its value, like that of beech soda pulp, lies especially in the properties of opacity, bulk, softness, and absorbency rather than strength (16).

Satisfactory dissolving pulps can be prepared from American beech by subjecting the wood to an acid hydrolysis prior to a normal kraft digestion. These pulps may be produced with various combinations of prehydrolysis time, temperature, concentration, and type of hydrolyzing agent. Manufacturers can select the combination of variables that will make possible a minimum production cost (37).

Extensive experimental work has been done in German mills on the production of rayon pulp from beech by the various pulping processes, including the sulfate and sulfite processes and prehydrolysis followed by sulfate pulping. Although the yield of pulp was found to be higher with the sulfate process, the total yield of products obtained from the wood, including, in addition to the pulp, yeast and other byproducts from the spent liquors, was even higher when using the sulfite process (1). Other investigators in Europe have also done much experimental work in the production of rayon pulps from beech by various methods. Beech

prehydrolysis sulfate pulps that had the chemical requirements for dissolving pulps were obtained by prehydrolysis treatments with steam, water, kraft spent liquor, and various mineral acids (5, 17, 18, 20, 22, 23). Most of these prehydrolysis sulfate pulps appeared to be more suitable for conversion to viscose rayon and cellophane than to acetate rayon.

SULFITE PULPING

Hardwood sulfite pulps are suitable for a variety of uses, though their utility is limited by their low strength. They are generally blended with other pulps in papers of moderate strength. Papers made from blends of hardwood pulps and long-fibered coniferous pulps have excellent formation and develop a good finish. Because fibers in hardwood sulfite pulps are not as soft as the corresponding fibers in soda pulps, they are better suited than soda pulps for blending in hard papers such as bond and ledger.

Beech is somewhat more difficult to cook by the sulfite process than are some other hardwoods, such as aspen or tupelo gum. Its dense structure slows penetration of the cooking liquor, so that a prolonged temperature rise and careful control are needed to avoid burning. Penetration is facilitated and pulps containing fewer screenings are obtained in a shorter time by using a more soluble base, such as ammonium, sodium, or magnesium, rather than the calcium base. Other means of aiding penetration, such as preevacuation of the digester and the use of smaller chips, have been proposed (19). Another advantage of soluble-base liquors is that a high concentration of base can be handled without danger of precipitating sulfite or sulfate, as happens in these circumstances when the calcium-base process is used.

When cooked by the sulfite process, beechwood gives a dark, weak pulp that is a little hard to bleach. Because of the high density of the wood, an excellent yield of pulp per cord of wood can be obtained. This yield may amount to 1,200 pounds, compared with 850 pounds from aspen wood and 920 pounds from spruce. If the equipment available is limited to producing a liquor of such concentration that the volume needed for a digester full of chips does not contain enough chemical, the digester must be only partly filled with chips. This, of course, lowers production. But if the acid system can produce cooking liquor of sufficient strength, the yield per digester charge can be made correspondingly higher.

The most complete data on the sulfite pulping of North American beech including chipping the wood and bleaching the pulp are reported by Richter (38). Of the several New England hardwoods that he cooked to equal lignin content, beech had the lowest yield with the greatest amount of screenings. The pulp was fairly low in pentosan content (6.6 percent), and low in strength; and the chlorine requirement in bleaching was somewhat greater than for the other hardwoods. A yield of 43.5 percent pulp and 3.4 percent screenings was obtained by using a soda-base liquor containing 5 percent free and 1 percent combined sulfur dioxide, a schedule of 5 hours to 140° C. and 3 hours at 140° C., and a maximum pressure of 75 pounds.

Richter (38) placed the strength of beech sulfite pulp below that of white and yellow birch and rock maple. This pulp had 50 percent as much bursting strength and 60 percent as much tearing strength as spruce sulfite of the same chlorine requirement. McGovern (26) reports the strength of beech sulfite as being about the same as that of aspen sulfite, which he rates at 50 to 60 percent as strong as spruce sulfite. Pfretzchner and associates (35) report that beech sulfite, after bleaching, has 70 percent as much breaking length as spruce sulfite and 10 percent as many double folds.

The literature shows that the sulfite pulping of beech has been thoroughly examined in Europe. In spite of all this investigation, a survey of hardwood utilization in western Europe published in 1949 by Atchison (1) disclosed that little or no beech was being used for paper pulps. On the other hand, a considerable tonnage of beech pulp was produced for chemical conversion. The cooking and bleaching practice used by the mills that pulped beech in western Germany was examined and reported upon by McGovern and Dickerman in 1946 (27). Countries in which this species is a major resource are persistently experimenting with different methods for the pulping of beech. Recent reports from such countries cover, for example, work done on the hydrolysis of the pulp by heating it in the presence of the hydrochloric acid formed in the chlorination stage of bleaching (43), and work on the sulfite pulping of the bark for viscose (24).

In North America, beech would probably be cooked in mixture with other hardwoods. Reports on the digestion of beech, birch, and maple in mixture date back to 1927 (13, 31, 32), and it has been recently claimed that the mixture cooks easily in about 7 hours when an ammonia-base sulfite liquor is used (7). Beech and maple are being pulped commercially with this base (9), and the product is being used in papers of a grade usually regarded as of too high a quality for the ordinary type of hardwood sulfite pulp.

NEUTRAL SULFITE SEMICHEMICAL PULPING

The neutral sulfite semichemical process includes digestion of wood chips, at temperatures near 170° C., with a solution containing sodium sulfite plus sufficient buffer, usually in the form of sodium bicarbonate, to keep the liquor slightly alkaline. The softened chips are then reduced to pulp by suitable mechanical means, such as by one or two passes through a disk mill. Surprisingly good pulps have been obtained by this method from a number of hardwoods. The pulps are bleached readily to medium brightness with little or no change in strength, and the strength developed by fully bleached pulps of some species rivals that of unbleached or bleached coniferous sulfite pulps (fig. 2).

Since hardwood semichemical pulp contains considerable hemicellulose, it tends to increase the hardness and brittleness and to lower the opacity of papers in which it is included. Therefore, it is well adapted for making glassine and greaseproof papers. Because of their short length, the hardwood fibers blend well in printing papers and enhance their printing quality.

Little information is available on the making of neutral sulfite semichemical pulp from beech. Aside from publications by Bouchayer (3, 4), who evaluated almost all his pulps for yield and brightness only, the available information is based on a few digestions made at the Forest Products Laboratory and the State University of New York College of Forestry at Syracuse.

Experiments at the Forest Products Laboratory showed that, in order to obtain a yield of pulp in the range usual for pulps used for corrugating board, the application of 10 percent of sodium sulfite (wood basis) with 6 or 7 percent of sodium bicarbonate was required. This is equivalent to 60 pounds of sulfur and 300 pounds of soda ash per ton of air-dry pulp. The amount of pulp obtained was 77 pounds per 100 pounds of wood on a moisture-free basis. Indications are that a pulp containing about 10 percent of lignin and suitable for bleaching can be obtained at a yield of 68 to 70 percent. The estimated chemical application in this case would be about 17 percent of sodium sulfite with 6 to 7 percent of sodium bicarbonate. Techniques for economical bleaching of pulps containing this amount of lignin are well established (40).

Beech semichemical pulp was found to be considerably weaker than pulps of similar yield made from such woods as aspen or birch. The available information shows that beech pulp will be somewhat weaker than pulp from soft maple or black cherry, species with which beech is often associated in the forest. However, the material has been found to be

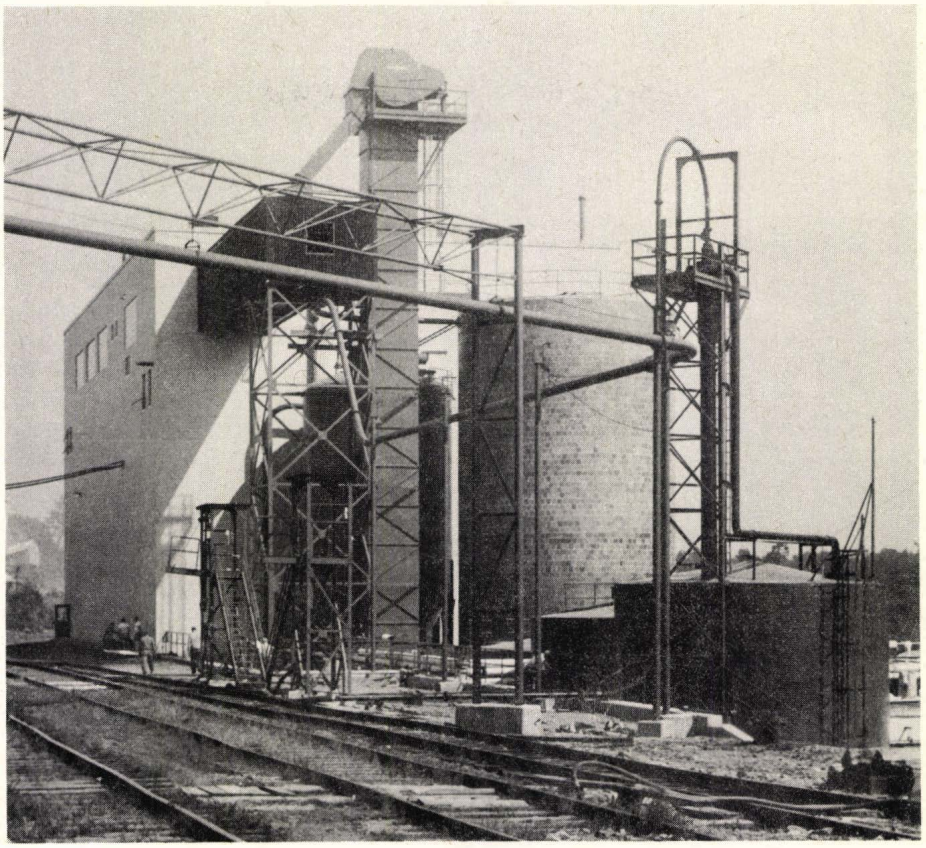

Figure 2.--A modern neutral sulphite pulp mill at Glen Falls, N.Y. Here hardwood is used exclusively, and about one-third of it is beech.

(Photo courtesy Finch, Pruyn & Co., Inc.)

as strong as--in fact, usually stronger than--several oak neutral sulfite pulps that have been examined. This is noteworthy because of the recent commercial developments in the use of oak for making neutral sulfite semichemical pulp.

Standard test sheets prepared from unbleached beech semichemical pulp in 77 percent yield at a Canadian Standard freeness of 250 milliliters had a bursting strength of 0.55 point per pound per ream,[4] a tearing resistance of 0.78 gram per pound per ream, and a folding endurance of 30 double folds. However, a different sample of beech, cooked to the

[4]Ream of 500 sheets 25 by 40 inches.

same yield, gave an unbleached pulp equal in tearing resistance but nearly 20 percent lower in bursting strength and 45 percent lower in folding endurance. Standard three-stage bleaching brought about the usual large increase in the strength of the semichemical pulp. The unbleached pulp mentioned first had, after it was bleached, a bursting strength of about 0.75 point per pound per ream, a tearing resistance of 1.1 grams per pound per ream, and a folding endurance of 100 double folds.

Unpublished data from experimental digestions made at the College of Forestry are presented in table 3. This table shows comparative values for white birch, American beech and European beech. At comparable unbleached yields, white birch pulps are higher in bursting strength than either of the beech pulps. When these pulps are bleached to essentially the same brightness, the spread in strength values between white birch and the beeches is not so marked.

Table 3.--Yields and strength values of experimental bleached and unbleached hardwood semichemical pulps

Wood species	Yield of screened pulp		Bursting strength		Tearing resistance		Brightness (Hunter)
	Unbleached	Bleached	Unbleached pulp	Bleached pulp	Unbleached pulp	Bleached pulp	
	Percent	Percent	Pts. per lb. per ream	Pts. per lb. per ream	Pts. per lb. per ream	Pts. per lb. per ream	Percent
White birch	59	50	0.84	0.80	1.32	1.31	80
	70	58	.55	.71	.90	1.13	81
	72	60	.64	.63	.90	1.14	81
American beech	59	50	.64	.87	1.20	1.42	77
	71	--	.51	--	1.02	--	--
European beech	61	51.5	.35	.70	.79	.95	83
	70	54.6	.28	.71	.56	.98	80
	72	52.0	.17	.70	.39	1.09	82

Since, in North America, beech occurs almost exclusively in mixed stands, and since segregation of species for pulping is expensive, most beech will probably be cooked in mixture. In the following paragraphs, the results of several small-scale investigations on naturally occurring mixtures are described.

Semichemical pulp was made from a mixture of eastern Michigan hardwoods composed of 20 percent beech, 60 percent hard and soft maples, and 20 percent yellow birch. This pulp, obtained at 78 percent yield, was made into corrugating board that was much stronger than strawboard, and somewhat stronger than corrugating board made from extracted chestnut.

Corrugating boards made from semichemical pulp obtained from a mixture of equal parts of beech, black cherry, and soft maple had roughly twice the bursting and tensile strength and slightly greater tearing strength than a good commercial corrugating board. The compression resistance of the experimental board was excellent. A linerboard made from the same pulp scarcely met specifications for bursting strength, and had very low tearing and folding strength. Compared at the same freeness with average unbleached sulfite pulp from coniferous woods, the unbleached semichemical pulp had about half the bursting and tensile strength and about the same tearing resistance, but only 6 percent of the folding endurance.

In other studies it was concluded that fully and partially bleached neutral sulfite semichemical pulp made from equal parts of beech, birch, and hard maple could be substituted--up to 100 percent in some cases--for the softwood sulfite pulp in groundwood book, newsprint, and greaseproof papers. It was also concluded from the semichemical pulping of a mixture of 15 percent each of beech, birch, red maple, and sugar maple and 40 percent of black cherry that, when fully bleached, the pulp could replace 25 percent or more of the commercial sulfite pulp in No. 1 bond papers. The yield of this hardwood pulp, on a wood basis, was 70 percent before bleaching and 55 percent after bleaching (29).

Though these results were obtained in small-scale experiments, it appears very likely that neutral sulfite semichemical pulp made in high yield from naturally occurring mixtures that contain appreciable proportions of beech can be blended into a large variety of products, ranging from corrugating boards through printing, greaseproof, and bond papers.

COMPARISON OF VARIOUS TYPES AND KINDS OF SEMICHEMICAL PULP

Hagglund compared beech and birch pulps made by the acid sulfite semichemical, neutral sulfite semichemical, and kraft semichemical processes at 70 percent yields (12). Beech pulps were considerably weaker than birch pulps. Unbleached acid sulfite semichemical pulps were the weakest. Unbleached neutral sulfite semichemical pulps were slightly superior to kraft semichemical pulps in breaking length and bursting strength, and slightly inferior in tearing resistance and folding endurance. After multistage bleaching with 15 percent of total chlorine, beech neutral sulfite pulp was about 10 percent weaker than acid sulfite pulp in breaking length and had only one-third as much folding endurance. It

was comparable with bleached kraft semichemical beech pulp except that it had only half the folding endurance. Bouchayer (4) also compared the strength of beech pulps prepared by the neutral, soda, and kraft semichemical processes. He obtained a yield of 80.7 percent by the neutral process and 72.4 percent by the kraft process, so it is not surprising that the kraft semichemical pulp had greater strength. After multistage bleaching, all pulps had similar strength properties.

NITRIC ACID PULPING

Pulp manufacturers in Europe are making nitrating pulps from beech by the standard nitric acid pulping process. These pulps are then blended with coniferous pulps and nitrated for the manufacture of cellulose nitrate. Mills in Germany and several countries in eastern Europe have been making this type of pulp for the last few years.

SUMMARY

American beech (Fagus grandifolia) can easily be converted into useful pulps by most of the processes currently in use or in development. Because of the natural characteristics of the wood, beech pulps are not equal in strength to similar pulps from other North American hardwoods and, in general, are not classed as high-quality pulps. However, they can be used to good advantage in mixture with other pulps. The short, fine fibers serve as a filler to produce a smooth surface and softness needed in some papers. Beech can be used also as a partial replacement for coniferous woods in the manufacture of the viscose grade of dissolving pulp. Although the amount of beech used in the manufacture of paper will undoubtedly be held to a minimum so long as large quantities of more desirable woods are available, technically there appears to be no reason why the current use of beech for pulp could not be substantially increased.

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AGRICULTURE-FOREST SERVICE-UPPER DARBY

(CONTINUED FROM INSIDE OF FRONT COVER)

* Chemistry and chemical utilization of beech.
* Silvicultural characteristics of beech.
  Availability and supply of beech.
  Present markets and uses for beech.
* Logging beech and specifications for products.
* Seasoning beech lumber.
* Storage of beech logs and bolts.
* Machining of beech.
* Milling of beech.
* Gluing techniques for beech.
* Steam-bending of beech.
  Preservative treatment of beech.
* Beech for flooring.
  Beech for furniture.
  Beech for turned products and novelties.
* Beech for veneer and plywood.
* Beech for fuel and charcoal.
* Beech for crossties.
* Beech for containers.
* Pulping and defiberization of beech.
* Rough construction on the farm with beech.

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The information gathered in this widespread cooperative project should be of great use to the wood-using industries of the regions where the wood of American beech is available.

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